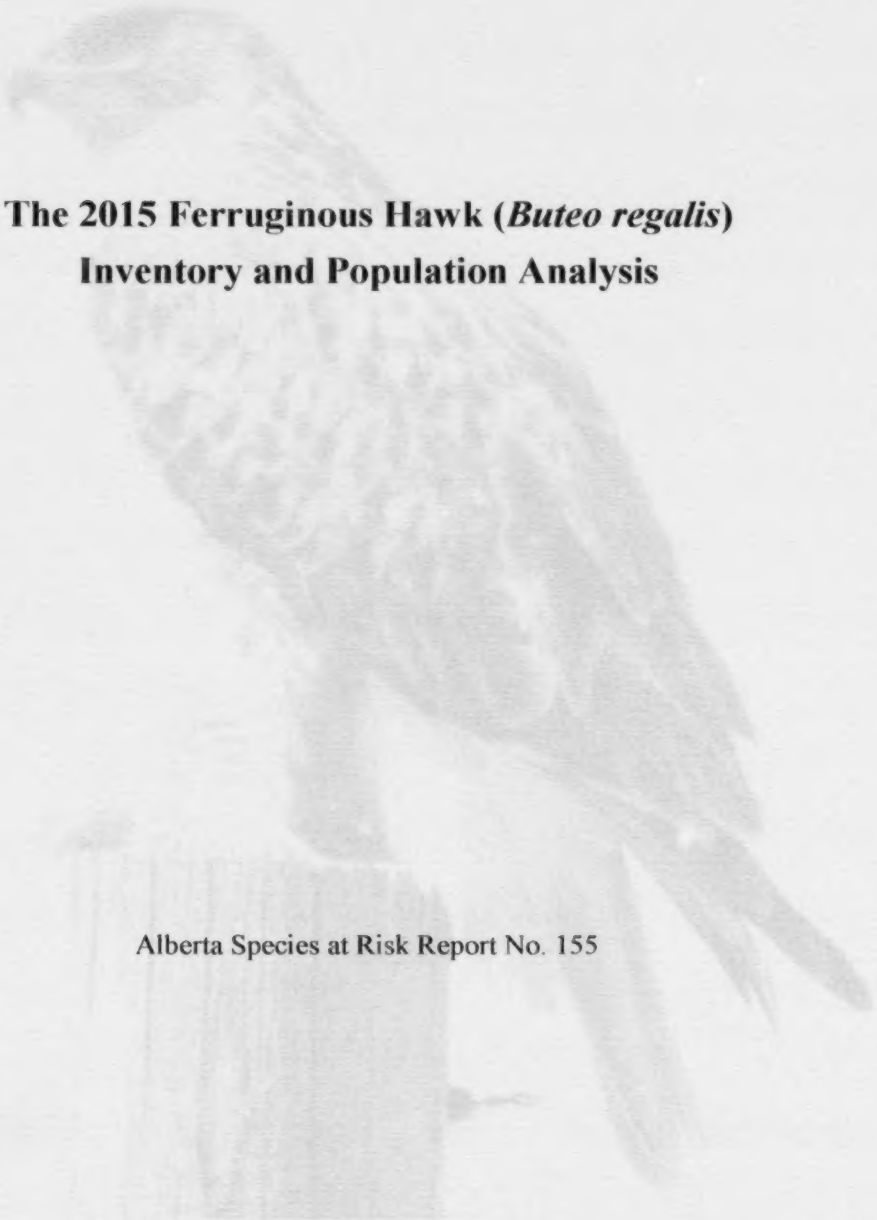
alberta's species at risk program

The 2015 Ferruginous Hawk (*Buteo regalis*) Inventory and Population Analysis



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The 2015 Ferruginous Hawk Inventory and Population Analysis

Melanie E. Redman

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Contact:
Information Center-Publications
Alberta Environment and Parks
Main Floor, Great West Life Building
9920-108 Street
Edmonton, Alberta, Canada T5K 2M4
Telephone: (780) 422-2079

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EXECUTIVE SUMMARY

The Ferruginous Hawk (*Buteo regalis*) occupies much of the Great Plains of North America, in which breeding almost exclusively occurs within grassland or shrub-steppe habitats. The largest Canadian Ferruginous Hawk range occurs in Southern Alberta, where their precence is associated with areas greater than or equal to 50% native prairie (ASRD and ACA, 2006). The Ferruginous Hawk is considered an *Endangered* species under Alberta's *Wildlife Act* (AEP, 2015) and is currently listed as a *Threatened* species in Canada by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (Government of Canada, 2015).

In 1983, Schmutz initiated the Alberta Ferruginous Hawk inventory to determine species distribution and abundance within the province. With the exception of years between 1993 and 1999, since 1982 population inventories for this species have been undertaken every 5 years. Population estimates are conducted in the spring, between May and July and are based on the number of confirmed active[1] Ferruginous Hawk nests (or breeding pairs).

The Ferruginous Hawk population estimates were above 1,700 pairs in 1987 and 1993. The inventory conducted in 2000 marked a significant reduction in the population with an estimate of just over 700 pairs. Since, the population has remained low, but stable between 600 and 800 pairs. The 2015 population inventory showed a slight, but insignificant increase to 865 pairs ± 201. Further research is required to confirm the cause for the slight increase. Although, initial analysis suggests it is related to a fluctuation of their primary prey species as a result of dry conditions of the previous year. Overall, Alberta's Ferruginous Hawk population remains significantly lower than the 1992 estimate, therefore, it remains essential for management actions to assist in the recovery of the species.

[1] "Active" in this context, describes a nest that is in use by Ferruginous Hawk at the time of the survey; this definition is different from that specified by the Ferruginous Hawk Recovery Team (AEP, in press)

ACKNOWLEDGEMENTS

The 2015 Ferruginous Hawk inventory would not have been possible without the assistance of many dedicated individuals.

I would like to recognise the landowners and leaseholders within the Grasslands Natural Region of Alberta that supported the surveyors in the field. The support of these individuals is critical in all wildlife management.

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INTRODUCTION

The Ferruginous Hawk (*Buteo regalis*) is the largest of the North American buteos (977 - 2,074g) occupying shrub-steppe regions and grassland habitats within the Great Plains of North America (Woffinden & Murphy, 1989; Schmutz et. al. 2008; Bechard & Schmutz, 1995). Ferruginous hawks are the only raptors of Alberta that use the grasslands as their main habitat; they are known to nest in areas of less than 50% cultivation and in concert to levels of their main prey, Richardson's ground squirrels (*Spermophillus richardsonii*) (Schmutz, Flockhart, Houstan, & McLoughlin, 2008; Downey, 2005). Land-use changes is suspected to be largely responsible for the slow reduction in breeding range and abundance of populations across North America (Woffinden & Murphy, 1989).

In Alberta, there has been a declining trend in the population (Schmutz et. al. 2008). In 2006, the species was provincially designated as *Endangered* under Alberta's *Wildlife Act* (ASRD and ACA, 2006).

Large scale population inventories were conducted in Alberta in: 1982, 1987, 1992, 2000, 2005, 2010, and 2015. The survey results showed a slight decrease from 1987 to 1992 and a significant decline from 1992 to 2000 (ASRD and ACA, 2006). Because of large confidence limits the accuracy of the survey methods were analysed and adjusted for the 2005 survey (Downey, 2005). There was an improvement in the confidence limits and the 2005 population estimate was found to be at its lowest on record at 618 ± 162 pairs (ASRD and ACA, 2006). The 2010 survey results showed the population remained low, but stable with an estimate of 618 ± 165 pairs (Moltzahn, 2010).

In this report we provide a current (2015) estimate on the number of Ferruginous Hawk breeding pairs in Alberta and evaluate the population trend to assess the effectiveness of the Alberta Ferruginous Hawk Recovery Plan 2009-2014 and develop recommendations for the Alberta Ferruginous Hawk Recovery Plan 2016-2020.

METHODS

Study Area

History

The 2015 study area consists of a south-eastern portion of Alberta and was derived from the Schmutz (1993) Ferruginous Hawk population trend report. This document provided the originally defined sampling frame expected to contain 95% of the provincial Ferruginous Hawk population. As per the recommendation of Sanders (2005), this study area remains to be used in population inventories. To accommodate technological advances since 1993, a version of this study area was created using ArcGIS 10.1 in order to provide for the 2015 and future Ferruginous Hawk inventories.

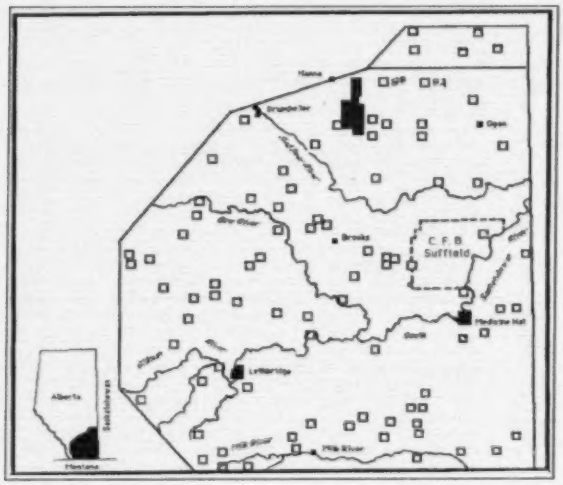


Figure 1: Original Ferruginous Hawk study area map from Schmutz (1993).

The map of the study area from Schmutz (1993) (Figure 1) was evaluated through a combination of quadrat, river, city and town locations to derive the new study area map (Figure 2). The original area calculations returned an estimated 77, 949 km². A new area measurement was calculated for the digital version of the study area; 77, 489 km². The two area values were compared and found to be insignificant in their size difference.

Beginning in the north east corner, the project area eastern edge runs south along the Alberta/Saskatchewan border east of Consort to the south eastern corner of Alberta, from here it runs west, along the Alberta/Montana border south of Cardston, north west to Pincher Creek, directly north to High River, runs north east through Strathmore, turns in a more easterly direction at Drumheller to Hanna, and makes its northern peak south of Veteran and heads east back to the Alberta/Saskatchewan border.

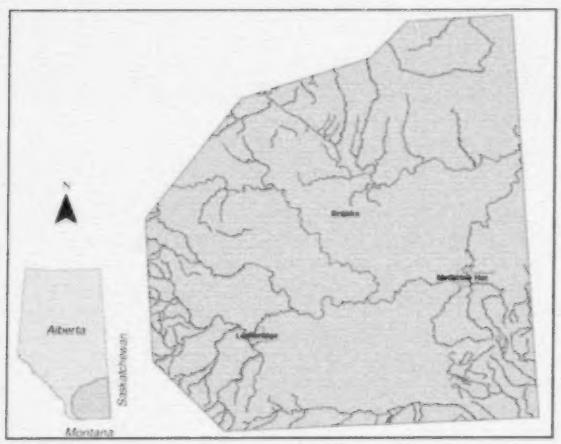


Figure 2: Digital version of the original (1993) study area developed in 2015.

Habitat

The habitat type contained within the study area largely consists of grassland, specifically: the grassland natural region, including portions of the Foothills Fescue, the Northern Fescue, the Mixed Grass and the majority of the Dry Mixedgrass region.

Land Uses

The primary land uses within the study area relate to agriculture, as a result, there are vast areas of cropland and tame pasture. Cultivation is considered a major factor affecting the population trends of Ferruginous Hawks (Schmutz J. K., 1984). However, oil and gas activity and its continued development in southern Alberta is an increasing risk (Moltzahn, 2010). The combination of these land

uses has reduced the amount of un-fragmented native prairie habitat. An assessment of the study area was completed using data from Agriculture and Agri-food Canada (2015). The result is an estimated 48% of the study area that consists of cultivated, or otherwise, area of poor to no habitat by way of non-native development or disturbance. Urban development accounts for 2% of the study area and the remaining 50% is a mix of largely fragmented, pastureland and native prairie and the small portion of coniferous that is the Cypress Hills (309 km²).

Stratification

After the 2000 population inventory, the quads were stratified into the 2 habitat strata (<50% and ≥50% native prairie) (Downey B. L., 2005). Up until this point, survey quads had not been stratified. The Native Prairie Vegetation Inventory (NPVI) provided the land use data. However, the NPVI data was based on an analysis of aerial photography from 1991-1993.

Land use was re-evaluated in 2015. The "non-cultivated" land was to represent area that is still native grassland, the habitat largely preferred by Ferruginous Hawks (Downey, 2005). Using data from Agriculture and Agri-Food Canada (2015) the study area land uses were assigned into one of three categories (Table 1). The reassessment provided current proportions of the low stratum (cultivated) and high stratum (non-cultivated) to be used in the population estimate[2].

Table 1: Land use categories for stratification - 2015 reassessment; Agriculture and Agri-Food Canada (2015)

Cultivated		Non-Cultivated	Urban Development
• Barley	• Pasture/Forages	• Broadleaf	• City
• Beans	• Peas	• Coniferous*	• Town
• Canary Seed	• Potatoes	• Exposed/Barren Land	• Village
• Canola/Rapeseed	• Rye	• Grassland	
• Corn	• Safflower	• Mixedwood	
• Fallow	• Soybeans	• Shrubland	
• Flaxseed	• Spring Wheat	• Water	
• Hemp	• Sugarbeets	• Wetland	
• Herbs	• Sunflower		
• Lentils	• Triticale		
• Mustard	• Winter Wheat		
• Oats			

*With the exception of Cypress Hills, a 309km² densely forested area unsuitable for Ferruginous Hawks.

[2] The Urban Development % was not considered as part of the study area in the population estimate; <2% of the study area fell into this category.

Survey Quadrats

The survey quadrats (also referred to as quads or blocks) within the sample area reflect the size and shape used in Schmutz (1993); 6.4 km by 6.4 km. Using the same Agriculture and Agri-food Canada data as the land use evaluation, the survey blocks were assigned as either low or high stratum. As recommended in Sanders (2005), the low strata quads are composed of less than 50% native prairie and the high strata quads are composed of greater than or equal to 50% native prairie[3]. Originally, 150 quadrats were selected for the 2015 inventory, a combination of historical quadrats (to retain consistency) and new quads (selected using a stratified random[4] sampling method). Two of the quads (#229, #259) had been removed because they fell outside of the original study area in Schmutz (1993). Another two quads (#8, #26) were removed from the population estimate due to the inability to access these areas. At the end of the survey period, a total of 146 quads were used for the 2015 Ferruginous Hawk population estimate, 79 of which were high strata and 67 low strata (Figure 3).

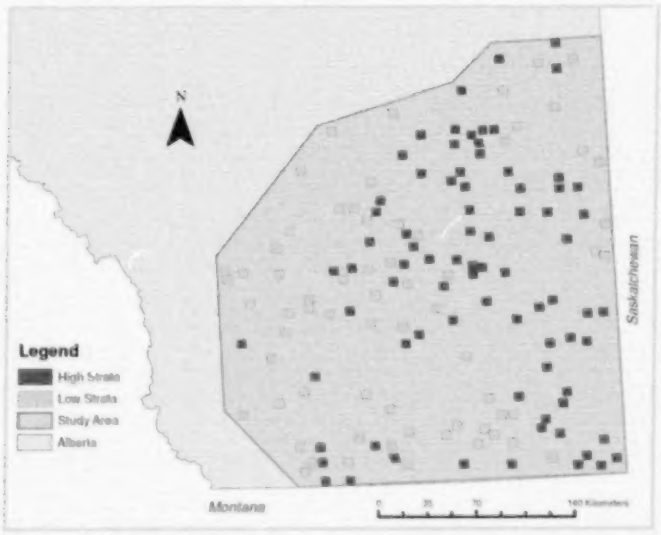


Figure 3: Surveyed quadrats during the 2015 Ferruginous Hawk population inventory

Surveyors

Quadrats were surveyed by trained observers of Alberta Environment and Parks (AEP), Alberta Conservation Association (ACA), University of Alberta's Raptor Ecology and Conservation Team (REACT), Blood Tribe staff, and Multiple Species at Risk (MULTISAR) staff. Each observer was provided their assigned quadrat location(s), survey protocol (Appendix A), data sheets (Appendix B), additional species to record (Appendix C), species identification, and equipment requirements.

In brief, these individuals were required to survey the quadrats assigned to them, recording coordinates of any active Ferruginous Hawk nests found. In addition, they were asked to record details pertaining to the nest site, any Ferruginous Hawk sightings and any additional sightings of interest (Appendix C).

---

[3] The area occupied by the Cypress Hills natural region (309.41 km^2) was removed from the total high strata (considered non-cultivated) and added to the low strata, as this is a large, predominantly coniferous area that is not preferred habitat by Ferruginous Hawks.

[4] Any new quads were selected to replace previous ineffective quads ie.expansion of urban area into quad, those outside of the historic study area or to increase sample size and were selected using an excel random number generator.

Data Analysis

The assumption was made that every active Ferruginous Hawk nest found represented one breeding pair. Krebs (1989) for stratified populations was utilized to provide a population estimate of Ferruginous Hawk breeding pairs in Alberta (Appendix D). This was the same method used in the Moltzahn (2010), and Downey (2005) population inventories. The data applied to this method included the size of the study area and of each stratum within the study area, the number of nests found within each stratum and of low/high strata blocks (Table 2).

Table 2: 2015 Ferruginous Hawk inventory data applied to Krebs (1989) for breeding pair population estimate

	Low Strata	*High Strata*	*Total*
Size within study area (km^2)	38,356	39,132	77,489
Number of quads surveyed	67	79	146
Size of strata sampled (km^2)	2,627	3,077	5,704
Number of nests found	14	52	66

RESULTS

Population Estimate

The resulting 2015 population estimate for Ferruginous Hawks in Alberta is 865 ± 201 breeding pairs. This is the highest population estimate of the last 4 inventories. Additionally, the 2015 inventory has the tightest confidence limits of all the past provincial inventories (Table 3). However, this estimate was not found to be significantly different from past inventories.

Table 3: The estimated number of Ferruginous Hawk breeding pairs in Alberta; 1982-2015

Year	*Number of Quadrats*	*Study Area (km²)*	*Estimated Number of Pairs*	*95% Confidence Limit*	*95% Confidence Intervals*
1982	80	74,686	1082	40.5	653-1511
1987	83	77,947	1791	28.5	1307-2275
1992	85	77,947	1702	30.6	1181-2223
2000	86	77,947	731	50.1	364-1097
2005	148	77,157	618	26.2	456-780
2010	142	77,947	618	26.7	453-783
2015	146	77,489	865	23.2	664-1066

Data retrieved from previous inventory reports:1982,1987, and 1992 (Schmutz J. K., 1993a)*; 2000 (Stepinksy et. al. 2002); 2005* (Downey B. L., 2005)*; 2010* (Moltzahn, 2010).

A total of 66 active Ferruginous Hawk nests were found, 14 of these were found on low strata blocks and 52 were found on high strata blocks (Figure 4).

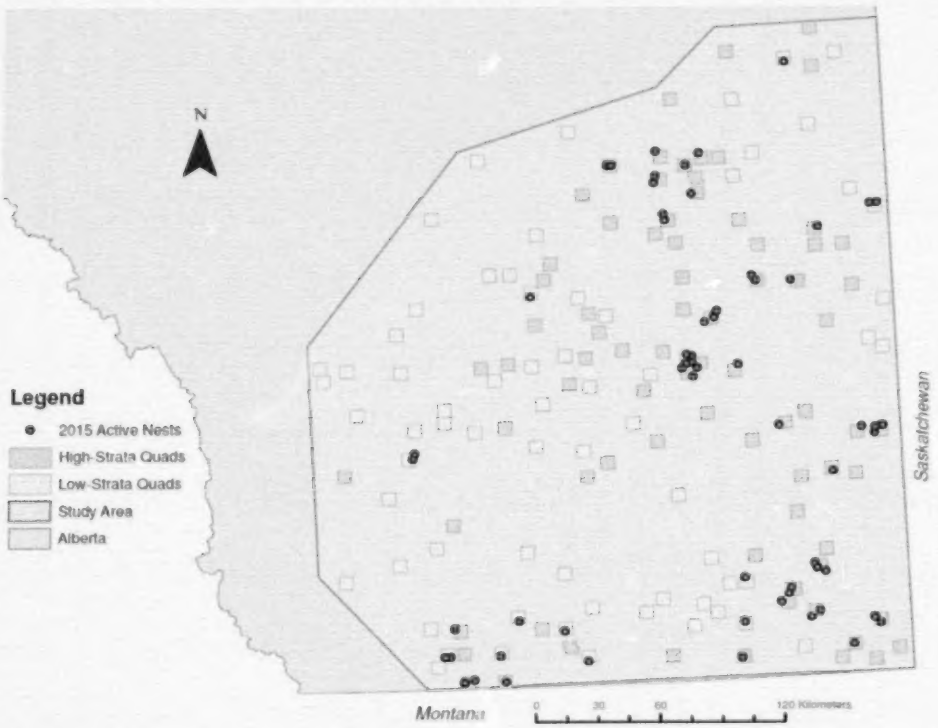


Figure 4: Resulting active nests of the 2015 Provincial Ferruginous Hawk Population Inventory

Population Trends

When comparing inventory data since 1982, using a linear regression analysis we see a declining trend (Figure 5). This was found to be the case in the last four Ferruginous Hawk population inventories. In 2010, the linear equation expressed a slope of -35.74 and 2015 demonstrates a slope of -27.48, suggesting that the overall rate of decline is less.

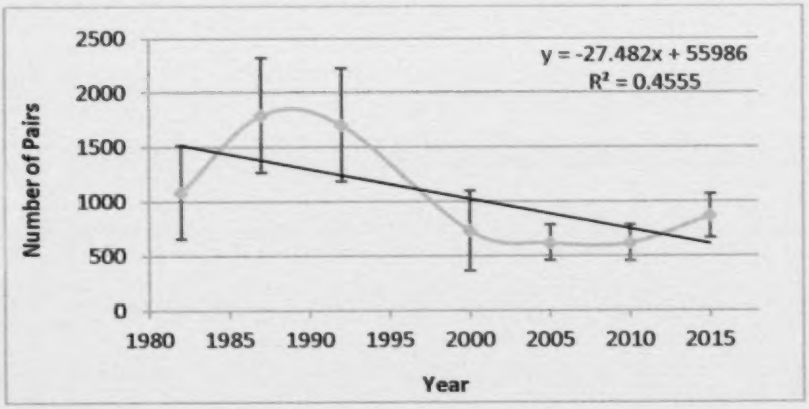


Figure 5: Population estimates of breeding Ferruginous Hawk pairs in Alberta 1982-2015

A comparison of the average number of active Ferruginous Hawk nests per block of the last three inventories was completed. The quads evaluated in this met the following criteria:

a) Those that had been surveyed 100% during the 2005, 2010 and 2015 inventories; and
b) Retained the same strata assignment since 2000.

This resulted in 101 blocks used for the comparison, 57 of which are high strata and 44 low strata (Appendix F).

The overall trend of the past three inventory years was developed using JMP®[5]. There was an overall positive trend, but no significant difference between the average number of nests per block from 2005, 2010 and 2015 (Figure 6).

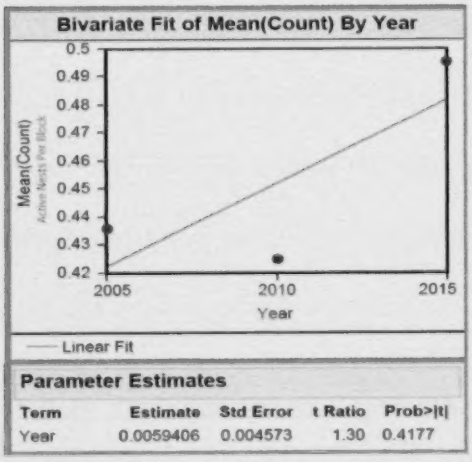
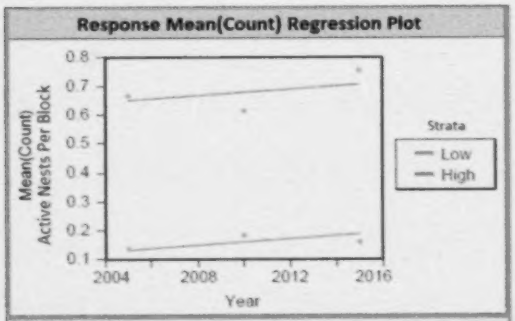


Figure 6: JMP® output graph and data; average number of active Ferruginous Hawk nests per block in 2005, 2010 and 2015 inventories

[5] JMP® is statistical discovery software from SAS® Institute. Information available at www.jmp.com

Evaluation of strata use

The same nest data used to establish the overall trend for average active nest per block was used to compare the trend of proportional use of high/low strata blocks by Ferruginous Hawk nesting pairs. This was done using JMP® (Figure 7).



Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Year	1	1	0.00304961	1.1382	0.3643
Strata	1	1	0.40446459	150.9605	0.0012 *

Figure 7: JMP® output graph and data; average number of active Ferruginous Hawk nests per block by strata in 2005, 2010 and 2015 inventories

These results show that:

- There is a significant difference of proportion of use between high and low strata ($p = .0012$), as previously established; Ferruginous Hawks prefer high strata blocks (majority native grassland habitat); and
- Comparing year to year data, the proportions in each stratum are not significantly different. Therefore, there has not been a change in proportion of use; no more Ferruginous Hawks are utilizing low quality habitat than the previous years (*Year* F Ratio = 1.13).

Land use re-evaluation effects

The land use re-evaluation of the study area resulted in changes to strata assignment of blocks and the percentage of each within the study area. Table 4 outlines the area of high and low strata within the study area during the 2005, 2010 and 2015 inventory years.

Table 4: Change of high and low strata area within the study area 2005, 2010 and 2015.

Inventory Year(s)	*Low Strata(km²)*	*High Strata(km²)*	*Total(km²)*
2005/2010	45,434	31,723	77,157
2015	38,356	39,132	77,488
Difference (%)	*-15.58*	*+23.36*	*-0.43*

Table 5 outlines the percentage of high and low blocks surveyed in the Provincial Ferruginous Hawk Inventories of 2005, 2010 and 2015 inventory years.

Table 5: Proportion of low and high strata area surveyed in Ferruginous Hawk population inventories.

Inventory Year	*Low Strata Blocks Surveyed (%)*	*High Strata Blocks Surveyed (%)*
2005	40	60
2010	53	47
2015	54	46

Contribution to Annual Data

Within six Alberta Fish and Wildlife Management Areas, 30 quadrats are surveyed annually for Ferruginous Hawk activity. These quadrats serve to represent a portion of the study area (Taylor, 2003). This data has been collected since 2003, providing an overall trend to which we can compare large-scale inventory trends.

This data demonstrates a very gradual decline from 2000 to 2015. The 2015 numbers show a slight increase.

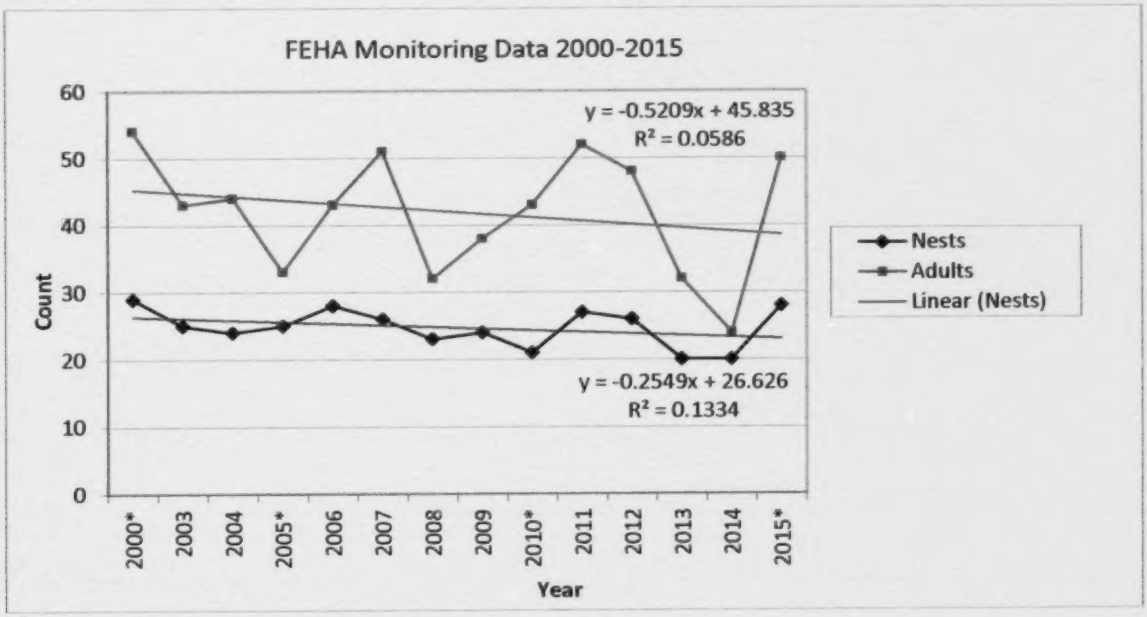


Figure 8: Annual Ferruginous Hawk Survey Data 2000-2015

Additional Species

Incidental observations were recorded during the Ferruginous Hawk surveys and entered into the Fisheries and Wildlife Management Information System (FWMIS). Surveyors were encouraged to record species of interest in addition to Ferruginous Hawks. However, as the project focus, only population estimates and other statistical analysis should be derived from the Ferruginous Hawk nest data. Additional observations included 34 different mammalian and avian species (Appendix E).

DISCUSSION

Comparing Inventory Data

The 2015 inventory population estimate of 865 ± 201 breeding pairs is the highest of the last four inventories. This estimate demonstrates a slight increase in trend since 2000 and shows a slower declining trend since 1982. An increase as small as this should not be taken as a sure sign of recovery, as wildlife populations often fluctuate (Yarrow, 2009). This modest increase was found insignificantly different from the two previous inventories. However, it would be unlikely, using 3 sequential inventories over a 15 year period for the population to increase drastically enough to be significantly different. Furthermore, this population estimate could be the beginning of a future increasing trend. The last 3 population estimates changed 85% (2000 to 2005), 0% (2005-2010) and now 140% (2010 to 2015). It is important to consider all possible reasons for these results, changes experienced between inventory years and what can be done to better understand them. The 2015 estimate may well be a result of natural occurrences, such as weather, inconsistencies in the methodology of the inventory processes, or cumulative influence of these.

Schmutz et. al, 2008, along with others, have confirmed the fluctuation of Ferruginous Hawk populations with their main prey, Richardson's ground squirrels (*Urocitellus richardsonii*). Drier weather will result in less vegetational growth providing the shorter vegetated, good visibility habitat that these rodents prefer; it is common for Richardson's ground squirrels to experience population outbreaks in drought seasons (Proulx, 2010). Considering the years previous to each inventory, it should then be reasonable to expect that the amount of precipitation in those years would fluctuate with the population estimates for the following year. Though this should be investigated independantly and in depth, a breif inquiry at the potential for such a relationship to exsist was undertaken using the Alberta Moisture Situation Updates by Alberta Agriculture and Forestry (AAF). To capture the nesting period of Ferruginous Hawks (ASRD and ACA, 2006), the first July reports (usually summarizing mid-June to mid-July) of 2014, 2009, and 2004 were read to decipher a general precipitation status at that time in Alberta. In 2004, there were "some areas of drought, where others remained normal". In 2009 there was "significant precipitation", and in 2014 "dry weather" across alberta was reported, "hitting 50 year lows" in some areas (AAF, 2015). This suggests the slight increase in population of Ferruginous Hawks in 2015 could be associated with the lack of precipitation the year before as it would potentially cause an increase in the Richardson's ground squirrel population. Some Ferruginous Hawk blocks were surveyed for Richardson's gound squirrels consistently between 2004-2006. Over this period, the population appeared to be declining in the grasslands region (Downey et. al. 2007). However, ground squirrel populations are not consistently assessed as part of Ferruginous Hawk Inventory, consistent Richardson's ground squirrel data could support the ability to determine cause of Ferruginous Hawk population fluctuations.

It should be considered that inconsistencies with methodologies could potentially account for some of the change in the population trend. The study area and quads had not been re-evaluated for land use until 2015. This changed the proportion of high and low strata in both the study area and the samples (quads) (Table 4). However, Krebs (1989) uses weighted means of each strata, so it should not significantly affect the estimate numbers had it been changed earlier.

To reflect the new land use data, the survey blocks were re-assessed and 29 were discovered to have changed stratum. The proportion of high and low stratum blocks that were surveyed in 2015 was similar to that surveyed in 2010. However, the proportions surveyed in 2005 was exactly the goal of 60/40 of high and low strata, respectively (Table 5). An ANOVA analysis of variation was conducted, there is significant similarity between the three sets of numbers (F=0.049; P-value=0.85).

Considering the Krebs (1989) method's ability to adapt using weighted means of strata and sample sizes, it is unlikely that the change in population is due to the methodology used during this inventory. It is possible that, what appears to be a population increase, is a natural fluctuation attributable to change in weather, but further research should be explored to confirm this hypothesis. The population increase should still be considered only with previous years of data, and statistically speaking, there is no significant change in the Ferruginous Hawk population since 2005.

Considering Annual Data

The annual data shows a similar trend to that of the Provincial Inventory data. In the 2010 Provincial Inventory, the annual nest count data from 2000 to 2010 demonstrated a slope of -0.47 with an R^2 value of 0.37 (Moltzahn, 2010). With the addition of annual data from 2011 to 2015 the slope has lessened to a value of -0.25 and the lower R^2 value of 0.13 suggests greater difference between the data (Figure 7).

The significance of change with the addition of the last years data would be difficult to test and maintain accuracy; the number of samples each year of the annual data changes slightly. However, this general trend does reflect what is witnessed with the inventory data. The decline is less and there is a small increase with the 2015 data. The assurance of consitency between the two sets of data, annual and inventory, demonstrates the likely accuracy of the inventory data.

Assessing Inventory Data

It should be noted that there are a few methods used every year that could affect the accuracy of each year's data. Nevertheless, consistency of method is more crucial as it can capture genuine population fluctuations over time (Gregory, Gibbons, & Donald, 2004).

Nest Location

The blocks are assigned to be high or low strata based on a majority rule; the original data unit is quarter section and each block contains 64. The strata that holds the majority of quarter sections within the block becomes the assigned strata for the entire 64 quarter sections. Because of this, the assumption is made that if the block has a nest on it, the chosen nest location by that breeding pair was on the strata assigned to the group of quarter sections, which may or may not reflect the habitat directly surrounding the nest.

Ferruginous hawk nesting occurs in significantly higher densities in areas with ≥50% native grassland/high stratum habitat (ASRD and ACA, 2006). Although Ferruginous Hawks can and have historically nested on or near the ground, these nests are found only to be utilized under extreme nest shortages (Schmutz et. al. 1988). Given the high quality habitat doesn't often provide nesting opportunities that low quality habitat may (ie. shelterbelts), it is possible that the nests may occur more often in areas where there is a mix of high and low. REACT (2015) noted such correlations, their results showed a nest abundance increase when the surrounding landscape of a nest site has multiple uses.

Strata use

The Ferruginous Hawk population inventories of 2005, 2010, and 2015 all demonstrated significant similarities in proportions of the population utilizing low strata blocks vs high strata blocks. Although the land use proportions changed and the population fluctuated slightly over these 10 years there is no indication of the Ferruginous Hawk being any more or less inclined to use low quality habitat. One extrapolation of this could be that without the high quality habitat the species may not be able to maintain its population although already widely recognised, confirming this further with a local population could support management goals in regards to habitat. Another, may be that there is a small portion of the population that maintains its ability to nest in these lower quality areas. In which case, their recruitment rates may be reduced. Further habitat assessment of the nest sites and fledging success rates may bring clarity to their ability (or inability) to produce successful recruits for the population. If it is found that a large portion of Ferruginous Hawks that nest in low quality habitat are not producing successful recruits, or are otherwise known as a "population sink" then this should be considered when assessing population estimates. REACT (2015) found a positive correlation between nest reoccupancy and amount of native grass surrounding the nest site.

This reflects the confusion of nest location within a survey quad in regards to surrounding habitat, as discussed in the previous section.

Stratification unit

As mentioned previously, a quads stratum is established on the majority strata of the 64 quarter sections. It should be noted that a stratum size within the study area is established by unit of quarter section. Therefore, the quads and study area are measured in two different units. Since the stratification of quads shortly following the 2000 Ferruginous Hawk inventory, this has been the method used. In this case, consistency of population estimates may be more valuable than the accuracy of that data.

RECOMMENDATIONS

In order to continue to improve upon our understanding of the Ferruginous Hawk population and in turn, our ability to manage it, the following recommendations should be considered for the future:

A full inventory should continue to be completed every five years.
Continuing the monitoring of the population is necessary to understand the population trends and effects of management initiatives. The next provincial inventory should be conducted in 2020.

Increase the number of quadrats to be surveyed in 2020
There are always some blocks that are unable to be surveyed because of weather conditions or access. Extra quads should be developed in both strata and surveyed in case of these situations.

A sub sample of quadrats should be surveyed annually

Annual monitoring of a sub sample of quadrats allows insight into the population dynamics between the 5-year studies (Taylor 2003). This can also be used to identify environmental factors, which may have altered population trends such as weather phenomena, change in prey densities, and nest site availability.

Master database of blocks and nests should be created

A database which contains information on nest history, location, pictures and survey history would be valuable to any further research in management tactics.

Investigate nesting opportunities available in high quality habitat/install artificial nest poles where needed.

Increasing nesting availability in the high quality habitats could support a healthy growth in the population. Establishing nest sites in large areas of pastureland or native grassland that did not previously have nesting opportunity (or historical sites has since been removed or damaged) for Ferruginous Hawks could increase the utilization of these quality habitats.

Richardson's ground squirrel populations and weather conditions should be monitored annually, or at least, in conjunction with future inventories.
Standardized ground squirrel surveys and weather data would provide available reasoning for some otherwise unconfirmed causes of population fluctuations.

Standardize record taking by surveyors and require photos of habitat and nest
Re-assess the surveying requirements to ensure all data is being provided similarly, and include information such as habitat surrounding nest site, whether the nest is artificial or natural, nest pictures and/or digital submission of coordinates to save time and lower risk of error during the data entry/analysis process.

Investigation of potential change in assignment of strata to blocks, or the consideration of immediate habitat in relation to Ferruginous Hawk nest location.
Include immediate habitat and nest type/pictures when data is collected to better understand the population and their nest location choices.

Accomplish recovery objectives set forth in the Ferruginous Hawk Recovery Plan 2016-2020
These objectives include, but are not limited to: sustaining 1,200 pairs of Ferruginous Hawks in Alberta by 2020, maintaining the current range of native grasslands in Alberta, and restoring native prairie where the opportunity is present (Alberta Ferruginous Hawk Recovery Team, in press).

Recruitment rates of Ferruginous Hawks should be investigated
The number of nestlings reaching fledging and ultimately becoming breeding adults remains unknown for Alberta's Ferruginous Hawk population. In collaboration with the province of Saskatchewan and the state of Montana, bird banding and GPS-tracking should be conducted on an annual basis to determine the success of nestlings reaching the fledging stage.

Within the Grassland Natural Region the Ferruginous Hawk should be considered a primary management species
Within the Grassland Natural Region of Alberta, the Ferruginous Hawk should be identified as a primary management species by government and conservation agencies. It is important that the habitat requirements of this species be incorporated into habitat conservation strategies of conservation organizations such as Operation Grassland Community, Alberta Conservation Association, Nature Conservancy of Canada, Duck Unlimited Canada, and others.

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Appendix A – Surveyor Protocol

Ferruginous Hawk Protocol

1. All quadrats are plotted on 1:250,000 maps as well as ArcView shape files.

2. Locate quadrat on map and identify if an ATV or mountain bike will be required.

3. Drive to quadrat and fill in start information: date, quadrat number, name of observer(s), start time, and general weather conditions. NOTE: Do not survey during periods of rain or winds ≥ 6 on the Beaufort scale.

4. Digital maps are provided for all quadrats. Please draw in any roads that are not indicated on the maps, and conversely cross off any indicated roads on the map that do not actually exist (use a felt tipped pen as most pens will not write on the digital image). Habitat maps are provided for all quadrats and habitat alterations should be updated on these maps. Habitat maps should include habitat type (cultivation vs. native prairie), trees, shrubs, coulees, wetlands, oil and gas developments and buildings.

5. Survey along roads first to identify all areas not visible from the road that require further searching. Use binoculars and spotting scopes to scan area to reduce disturbance to nesting birds.

6. Consult the landowner(s) before investigating areas not visible from the road. Large coulees and eroded banks can be searched by walking/driving/biking along the top and bottom of embankments stopping intermittently to scan with binoculars for nests. Gently undulating grasslands can be searched by walking/driving/biking along ridges or across hilltops.

7. Mark Ferruginous Hawk observations as well as the additional grassland species of interest on the Ferruginous Hawk Data Sheet and plot the ID number on the Map Data Sheet. Use a GPS unit to record observations using Universal Transverse Mercator (UTM) coordinates in NAD 83. Record the number of nests, adults, and young (if visible) at the site, as well as the activity and color phase of all birds. Please also indicate the nest ID number if this is a known nest (ID numbers are found on the digital maps). Any new FEHA nests not indicated on the digital maps should be given a six number nest ID, in which the first two numbers indicate the block number, the second two numbers indicate the year, and the third two numbers indicated are sequential, beginning at number 1, with all groups of numbers being separated by a hyphen. For example, if two new nests are located in block 24, first nest ID would be 24-08-01 and the second nest ID would be 24-08-02. If an active raptor nest is found fill in a Raptor Nest Site Habitat Data form. If a bird is a juvenile, record under the young category but indicate that it was a juvenile. Also, if possible, take a photograph of nests.

8. After a quadrat has been surveyed, prepare the summary information using the information collected on the Ferruginous Hawk Data Sheet. Attach any photographs taken within the quadrat.

9. Return data and map sheets to Alberta Fish and Wildlife Division in Lethbridge (Brandy Downey) for data analysis and storage.

Appendix B: Data Sheet

Ferruginous Hawk Data Sheet

Date (DDMMYY): Quadrat #: Start Time: End Time:

Observers: Total Hours:

General Weather Conditions:

Habitat Summary % Cultivation: % NP: % Tame:

% Not Surveyed:

Are potential nesting structures present? Description:

Site Photo Taken?

Site Photo Coordinates and Direction:

Species Summary Species Nests Adults Young

Species Observations						UTM	Nad 83
ID	Species	Nests	Adults	Young	Activity	Easting	Northing
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							

Observer Comments:

Appendix C: Additional Species List

Common / Latin names	Spp. Code
American Badger / *Taxidea taxus*	BADG
Baird's Sparrow / *Ammodramus bairdii*	BDSP
Bobcat / *Lynx rufus*	BOBC
Bobolink / *Dolichonyx oryzivorus*	BOBO
Bullsnake / *Pituophis catenifer*	BULL
Burrowing Owl / *Athene cunicularia*	BUOW
Golden Eagle / *Aquila chrysaetos*	GOEA
Great Blue Heron / *Ardea herodias*	GBLH
Loggerhead Shrike / *Lanius ludovicianus*	LOSH
Long-Billed Curlew / *Numenius americanus*	LBCU
Long Tailed Weasel / *Mustela frenata*	LTWE
Mountain Plover / *Charadrius montanus*	MTPL
Peregrine Falcon / *Falco peregrinus*	PEFA
Piping Plover / *Charadrius melodus*	PIPL
Prairie Falcon / *Falco mexicanus*	PRFA
Prairie Rattlesnake / *Crotalus viridis*	PRRA
Pronghorn / *Antilocapra americana*	PRON
Red-tailed Hawk / *Buteo jamaicensis*	RTHA
Sage Grouse / *Centrocercus urophasianus*	SAGR
Sage Thrasher / *Oreoscoptes montanus*	SATH
Sandhill Crane / *Grus canadensis*	SACR
Sharp-tailed Grouse / *Tympanuchus phasianellus*	STGR
Short-eared Owl / *Asio flammeus*	SEOW
Sprague's Pipit / *Anthus spragueii*	SPPI
Swainson's Hawk / *Buteo swainsoni*	SWHA
Swift Fox / *Vulpes velox*	SWFO
Thirteen-lined Ground Squirrel / *Spermophilus tridecemlineatus*	TLGS
Trumpeter Swan / *Cygnus buccinator*	TPSW
Upland Sandpiper / *Bartramia longicauda*	UPSA

Appendix D: Stratified Random Sampling (Krebs 1989)

The following formulas were used to calculate the population estimate of Ferruginous Hawk in Alberta. For full explanation please refer to Krebs (1989) method for a stratified population estimate.

A) Population total: sum of the population estimate for each stratum.

$$X_{st} = Nx_{st}$$

X_{st} = Population Total
N = Number of sample units in the entire population
x_{st} = Stratified mean/sampling unit

B) The overall mean/sampling unit for the population: the mean number of individuals observed per stratum.

$$x_{st} = \frac{\sum_{h=1}^{L} N_h x_h}{N}$$

x_{st} = Stratified population mean/sampling unit
N_h = Size of stratum h
h = Stratum number
x_h = Observed mean for stratum h
N = Total population size = $\sum N_h$

C) Stratum Weight: percent of total area in each stratum.

$$w_h = \frac{N_h}{N}$$

N_h = Size of stratum h
N = Size of entire statistical population

D) Variance of a stratified mean: variance of the mean number of individuals/ stratum

$$\text{Variance of } (x_{st}) = \sum_{h=1}^{L} \left[\frac{w_h^2 s_h^2}{n_h} (1 - f_h) \right]$$

w_h = Stratum weight
s_h^2 = Observed variance of stratum
n_h = Sample size of stratum h
f_h = Sampling fraction in stratum h= n_h/N_h

E) Variance of the Population Mean: variance of the entire population.

Variance of the Population Mean (X_{st}) = $(N)^2$(variance of x_{st})

F) Standard Error: required to determine the confidence limits

Standard Error of (x_{st})= $\sqrt{\text{variance of } x_{st}}$

G) Effective Degrees of Freedom: required to determine the value of t (95% CI).

$$\text{d.f.} \approx \frac{\left(\sum_{h=1}^{L} g_h s_h^2\right)^2}{\sum_{h=1}^{L} \left[g_h^2 s_h^4/(n_h - 1)\right]}$$

$g_h = N_h(N_h - n_h)/n_h$
s_h^2 = Observed variance in stratum h
n_h = Sample size in stratum h
N_h = Size of stratum h

H) Confidence limits for entire population

$X_{st} \pm t_\alpha$ (standard error of X_{st})

Appendix E: Incidental Observations

Spp. Code	Species	Scientific Name	Count
AMKE	American Kestrel	*Falco sparverius*	2
AWPE	American White Pelican	*Pelecanus erythrorhynchos*	1
BADG	Badger	*Taxidea taxus*	2
BRSW	Barn Swallow	*Hirundo rustica*	1
BRTH	Brown Thrasher	*Toxostoma rufum*	1
CEWX	Cedar Waxwing	*Bombycilla cedrorum*	2
CCLO	Chestnut-Collared Longspur	*Calcarius ornatus*	1
CONI	Common Nighthawk	*Chordeiles minor*	1
CORA	Common Raven	*Corvus corax*	11
COSN	Common Snipe	*Gallinago gallinago*	2
EAKI	Eastern Kingbird	*Tyrannus tyrannus*	1
GOEA	Golden Eagle	*Aquila chrysaetos*	9
GRPA	Gray Partridge	*Perdix perdix*	34
GHOW	Great Horned Owl	*Bubo virginianus*	20
LOSH	Loggerhead Shrike	*Lanius ludovicianus*	21
LBCU	Long-Billed Curlew	*Numenius americanus*	8
MCLO	McCown's Longspur	*Calcarius mccownii*	1
MERL	Merlin	*Falco columbarius*	6
NOHA	Northern Harrier	*Circus cyaneus*	45
NOPI	Northern Pintail	*Anas acuta*	24
NOSK	Northern Shrike	*Lanius excubitor*	1
PEFA	Peregrine Falcon	*Falco peregrinus*	6
PRON	Pronghorn	*Antilocapra americana*	38
RTHA	Red-Tailed Hawk	*Buteo jamaicensis*	106
RGNP	Ring-Necked Pheasant	*Phasianus colchicus*	1
STGR	Sharp-Tailed Grouse	*Tympanuchus phasianellus*	47
SEOW	Short-Eared Owl	*Asio flammeus*	1
SORA	Sora	*Porzana carolina*	1
SPPI	Sprague's Pipit	*Anthus spragueii*	18
SWHA	Swainson's Hawk	*Buteo swainsoni*	213
TUVU	Turkey Vulture	*Cathartes aura*	1
UPSA	Upland Sandpiper	*Bartramia longicauda*	10
WAPT	Wapiti	*Cervus elaphus*	4

Appendix F: Blocks used in population trend and strata use analysis

Block#	Strata	2015	2010	2005
1	High	2	1	2
2	High	1	1	1
3	Low	0	0	0
4	High	2	0	0
5	Low	0	0	0
6	Low	1	1	1
11	Low	1	1	1
12	Low	0	0	0
13	Low	0	0	0
14	Low	0	1	1
15	Low	0	0	0
16	Low	0	0	0
17	Low	0	0	0
18	Low	1	0	0
19	High	0	0	1
23	Low	0	0	0
30	Low	0	0	0
33	Low	0	0	0
34	Low	0	1	0
35	Low	0	0	0
36	Low	0	0	0
37	Low	0	0	0
38	Low	0	0	0
39	Low	0	1	0
40	Low	0	0	1
41	Low	2	2	1
42	Low	0	0	1
44	Low	0	0	0
45	High	0	0	0
46	Low	0	0	0
47	Low	0	0	0
48	Low	0	0	0
49	High	0	1	0
50	Low	0	1	0
52	High	0	0	0
53	Low	0	0	0
54	Low	1	0	0
58	High	0	1	0
60	High	4	4	5
61	High	2	2	2
62	High	1	0	0
65	High	0	0	0
66	High	1	1	2
67	High	1	1	2
69	High	4	4	2
71	Low	0	0	0
73	High	0	0	0
74	High	0	0	0
75	Low	0	0	0
76	Low	0	0	0
77	Low	0	0	0
79	Low	1	0	0
80	High	0	0	0
88	High	0	0	0
89	High	1	2	2
92	High	2	2	1
93	High	2	0	1
94	High	0	0	1
96	High	0	0	0
97	Low	0	0	0
98	High	0	0	0
101	Low	0	0	0
105	Low	0	0	0
107	Low	0	0	0
108	Low	0	0	0
112	Low	0	0	0
202	Low	0	0	0
206	High	0	0	1
209	High	0	0	0
210	High	2	1	2
212	High	3	1	2
214	High	2	2	1
215	High	1	0	0
216	High	1	1	0
218	High	0	0	0
219	High	2	1	3
222	Low	0	0	0
224	High	4	2	0
230	High	0	0	1
231	High	0	0	0
233	High	0	0	1
234	High	0	1	0
236	High	0	0	0
237	High	0	0	0
239	High	0	0	0
243	High	0	0	0
244	High	0	0	0
246	High	0	0	1
248	High	0	0	0
249	Low	0	0	0
251	High	0	0	0
252	High	0	0	1
253	High	0	0	0
254	High	0	0	0
255	High	1	0	1
258	High	2	2	0
261	High	0	0	0
262	High	1	3	2
263	High	0	0	0
266	High	0	0	0
267	High	1	1	0
		50	43	44

Total # of Blocks:	*101*
# of High	*57*
#of Low	*44*

For a list of additional reports in the Alberta Fish and Wildlife Species at Risk Report Series, please go to the website:

http://esrd.alberta.ca/fish-wildlife/species-at-risk/species-at-risk-publications-web-resources/default.aspx